

September 25, 2003

FOLSOM OUTLET RELEASE DURING FALL 2002 TO PROVIDE COLD WATER FOR SALMONID RESOURCES IN THE LOWER AMERICAN RIVER

Background

Throughout the summer of 2002 the U.S. Bureau of Reclamation and the CALFED Management Agencies (U.S. Fish and Wildlife Service (FWS), California Department of Fish and Game (DFG), and National Marine Fisheries Service (NMFS)) met with the American River Operations Group (AROG) to discuss the management of water temperatures in the lower American River below Nimbus and Folsom Dams to maintain suitable rearing conditions for overwintering juvenile steelhead. The NMFS Biological Opinion requires water temperature compliance below Nimbus Dam to protect juvenile steelhead between June 1 and November 30. Reclamation attempted to maintain temperatures at or below 65° F (measured at the Watt Avenue Bridge) using temperature shutters installed over the power penstock inlet ports on Folsom Dam. As the summer progressed Reclamation used the temperature shutters to blend cold water from the lower portions of the reservoir with higher temperature water to try to meet the water temperature objective at the Watt Avenue Bridge. By October the cold-water pool available to the temperature shutters was almost exhausted and adult fall-run chinook salmon were returning to the lower river to spawn. River temperatures in mid-October ranged from 62 - 65° F. These elevated water temperatures may cause prespawning mortality and reduce embryo viability (U.S. Fish and Wildlife Service, 1995.). These temperatures also exceed the 60° F criteria that is generally accepted by Central Valley fishery biologists as the maximum temperature at which chinook salmon will initiate spawning in the lower American River. See Figures 1 and 2 from Snider et.al. 1995.

The thermal requirements for Chinook salmon in the Central Valley have been evaluated in a few thermal physiological studies. In 1997 A.A. Rich reported to the California State Water Resource Control Board that thermal stress for migrating adult salmon had been reported at temperatures beginning at 59° F, and that temperatures demonstrated to be lethal began at 62.6° F. Incubating eggs were even more sensitive, and temperatures demonstrated to be lethal to incubating eggs began at 55° F (Rich, A.A. 1997). Rich based her testimony on results of thermal studies both within the Sacramento-San Joaquin River system and elsewhere indicating that constant exposure of salmonid eggs to temperatures above 13° C (55-56° F) will result in some egg mortality. See Figure 3, cited in U.S. Fish and Wildlife Service. 1995.

On October 24, 2002 the AROG recommended that a river outlet release from Folsom Dam be initiated to improve temperature conditions needed to provide suitable spawning habitat for fall-run chinook salmon in the lower American River. As a result of Folsom Reservoir cold-water pool supplies being significantly diminished, the only available cold water (less than 50,000 acre-feet (AF) of water below 60°F) existed below the temperature shutters. See Figure 4. Access to the cold-water pool once it is below the temperature shutters is through releases from Folsom Dam's lower river outlets which bypasses power generation. Consequently, AROG requested that the CALFED Agencies use Environmental Water Account (EWA) assets to pay for the foregone generation resulting from a river outlet release. The CALFED agencies concurred, and on October 25 a Folsom Dam river outlet located below the temperature shutters was

opened and approximately 500 cfs of the remaining cold-water pool (at approximately 49°F) was released resulting in a bypass of power generation. An additional 1,000 cfs continued to be released through the temperature shutters and penstocks. See Figure 5.

It took about three days for the cooler water released at Folsom on October 25 to circulate through Lake Natoma and decrease river temperatures at Nimbus Dam and the Watt Avenue Bridge. On October 25, the daily mean temperature below Nimbus Dam was 62°F and by October 28 had decreased to 59°F. The daily mean temperature at Watt Avenue Bridge on October 25 was 63° F and by October 29 had decreased to 60° F. Temperatures at Watt Avenue Bridge remained in the 57-59° range until the river outlet release was discontinued on November 19, 2002. See Figures 6 and 7. These water temperatures and flows were maintained in order to improve fall-run chinook salmon spawning habitat and provide sufficient flows over salmon redds during the egg incubation period.

The water released through the Folsom Dam lower river outlets did not generate hydroelectric power and represented a lost amount of energy to the Central Valley Project (CVP). The total amount of CVP water bypassed was 26,500 acre-feet. The amount of power foregone during this action was 6.52 GWH. EWA funds were used to compensate the Western Area Power Administration for lost power generation. EWA water was not used in this action.

Discussion

It is estimated that the 2002 river outlet release at Folsom Dam decreased temperatures in the lower American River and improved spawning conditions for fall-run Chinook salmon about 12 days earlier than what would have occurred without the bypass. See figure 8. Prior to the river outlet release, temperatures in the river were approximately 63° F, which is above the 60° F spawning criteria and may have contributed to pre-spawning mortality. Within three days, temperatures in the lower American River had dropped to 60° F and remained in the 57-59° F range for the duration of the bypass.

In the fall of 2001 a similar situation took place, in which conventional temperature shutter operations were unable to maintain suitable temperatures in the lower American River during the salmon spawning season. Temperatures in the lower river in early November averaged 65° F and a significant pre-spawning mortality was reported by DFG. A lower river outlet release took place between November 10-26, which resulted in a decrease in lower river temperatures to 60° F by November 17. See Figure 9.

It should be noted that conditions in 2001 were much worse than they were in 2002. Overall storage behind Folsom Dam was low (271 TAF), there was a very small cold-water pool (21 TAF) and releases to the lower American River were only 1,000 cfs.

	<u>2001</u>	<u>2002</u>
Date river outlet release started:	November 10	October 25
Folsom storage prior to outlet release:	270 TAF	464 TAF
Est. cold-water pool (<60°F)	21 TAF	50 TAF
Avg. water temp at Watt Br. prior to outlet release:	63.7°F	62.7°F
Average daily air temperature:	61°F	61°F
Total release to River:	1,000 cfs	1,500 cfs
Fall-run escapement (preliminary):	130,785	118,114
Pre-spawn mortality (preliminary):	67%	30%

In hindsight, it could be argued that the river outlet release in 2001 should have been initiated sooner. The AROG knew that pre-spawning mortality was taking place, but did not know the severity of the problem. They were also keenly aware that the cold-water pool was limited and were concerned that the cold water would be exhausted before the spawning season was over and/or natural fall cooling would start to drop river temperatures. Given the circumstances the AROG made their request based on what the group thought was the best use of the remaining cold water.

In 2002 more cold-water assets were available and the group used what they had learned from their experience in 2001 to initiate the river outlet release earlier in the season. Even with more cold water and a relatively early bypass, pre-spawning mortality was still approximately 30%.

In both years DFG biologists reported that spawning initiated when river temperatures approached 60°F. The river outlet release operations in 2001 and 2002 were successful in decreasing water temperatures in the lower American River and improved spawning conditions for fall run chinook salmon.

Literature Cited:

Rich, A.A. 1997. Appendix A. Water Temperature Requirements for Chinook Salmon and Steelhead Trout. Testimony of Alice A. Rich, PH.D., Submitted to State Water Resources Control Board. July 1997. 14 pp.

Snider, B. and K. Vyverberg. 1995. Chinook salmon redd survey: lower American River, fall 1993. California Department of Fish and Game, Environmental Sciences Division, Stream Flow and Habitat Evaluation Program. Sacramento, CA.

U.S. Bureau of Reclamation. 1992a. Long-term Central Valley project operations criteria and plan CVP-OCAP. October 1992. Sacramento, CA.

U.S. Fish and Wildlife Service. 1995. Working paper: habitat restoration actions to double natural production of anadromous fish in the Central Valley of California. Volume 2. May 9, 1995.

Yaworsky, Russ. Hydrologist. U.S. Bureau of Reclamation, Sacramento, CA. Temperature summaries for Folsom Lake and lower American River, and graphs of estimated temperature effects of river outlet blending in 1991 and 1992. Information provided to the American River Operations Group in 2001 and 2002.

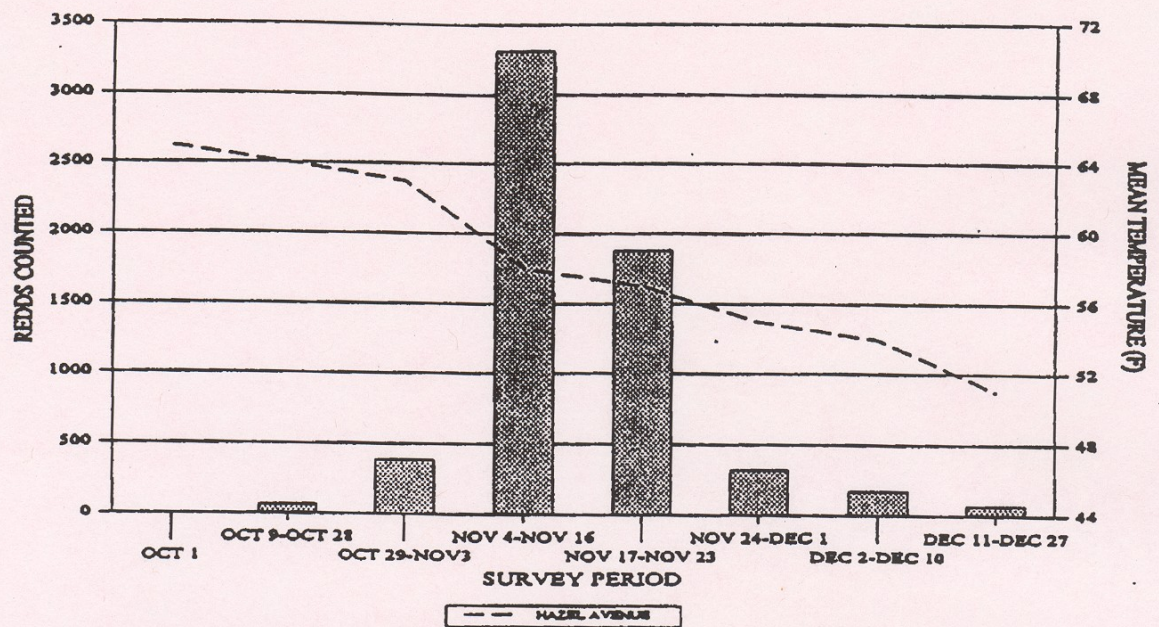


Figure 1. Number of fall-run chinook salmon redds versus mean temperature during each survey period, lower American River, fall 1993.

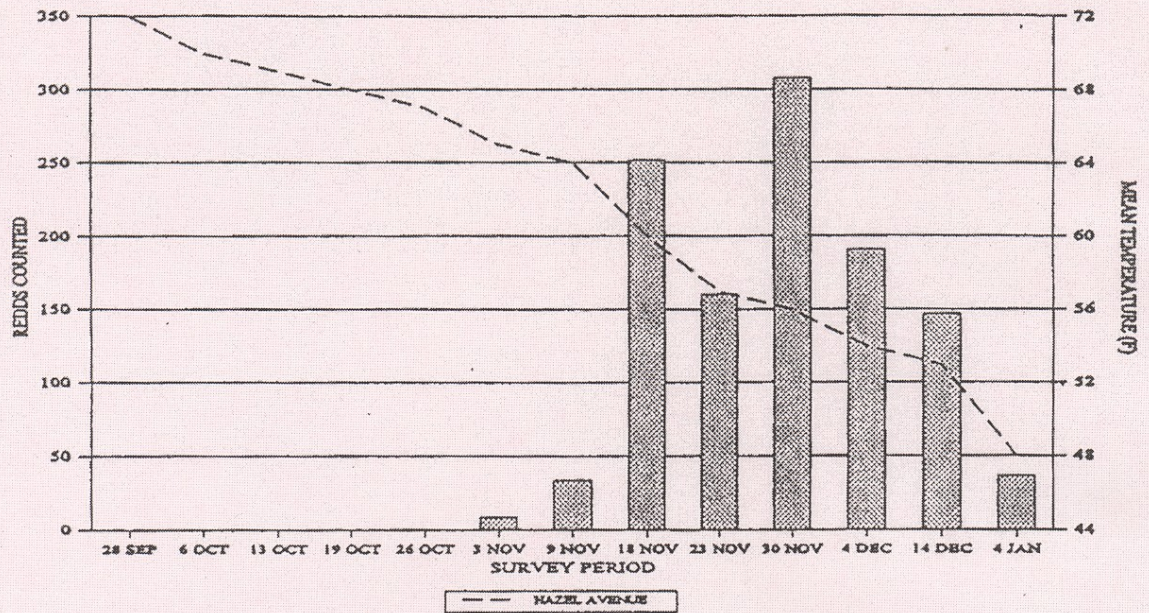
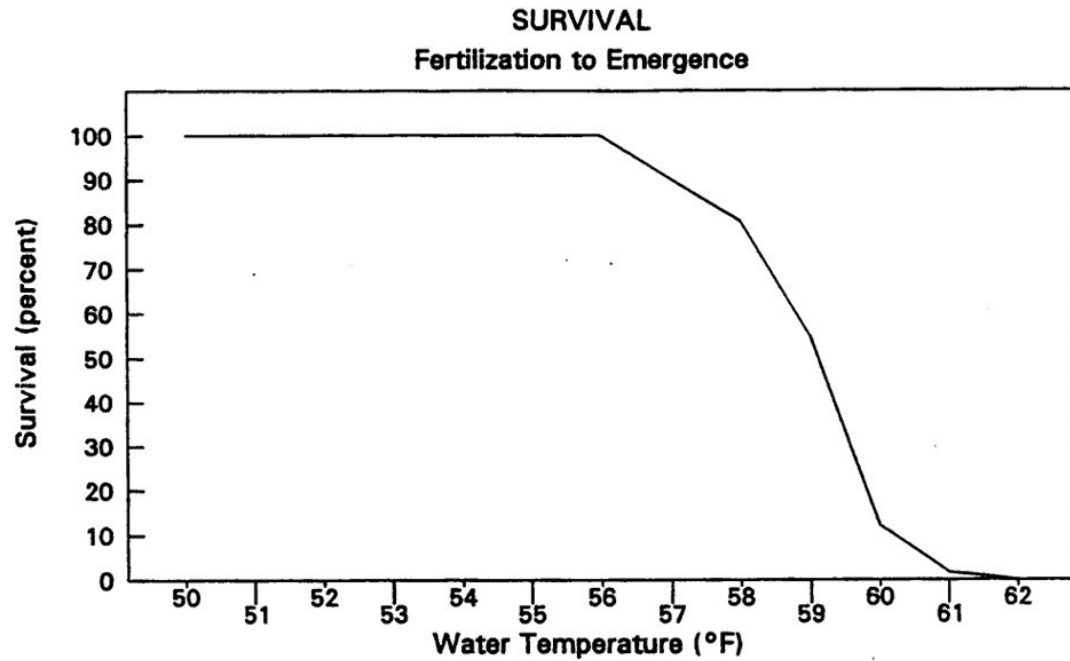


Figure 2. Number of fall-run chinook salmon redds versus mean temperature during each survey period, lower American River, fall 1992.

FIGURE 3 CHINOOK SALMON EGG AND LARVAL
DEVELOPMENT TIME AND SURVIVAL VERSUS WATER
TEMPERATURE



SOURCE: U. S. Bureau of Reclamation 1982a.

FIGURE 4.

Folsom Lake Temperature Profiles
October 18 & November 1, 2002

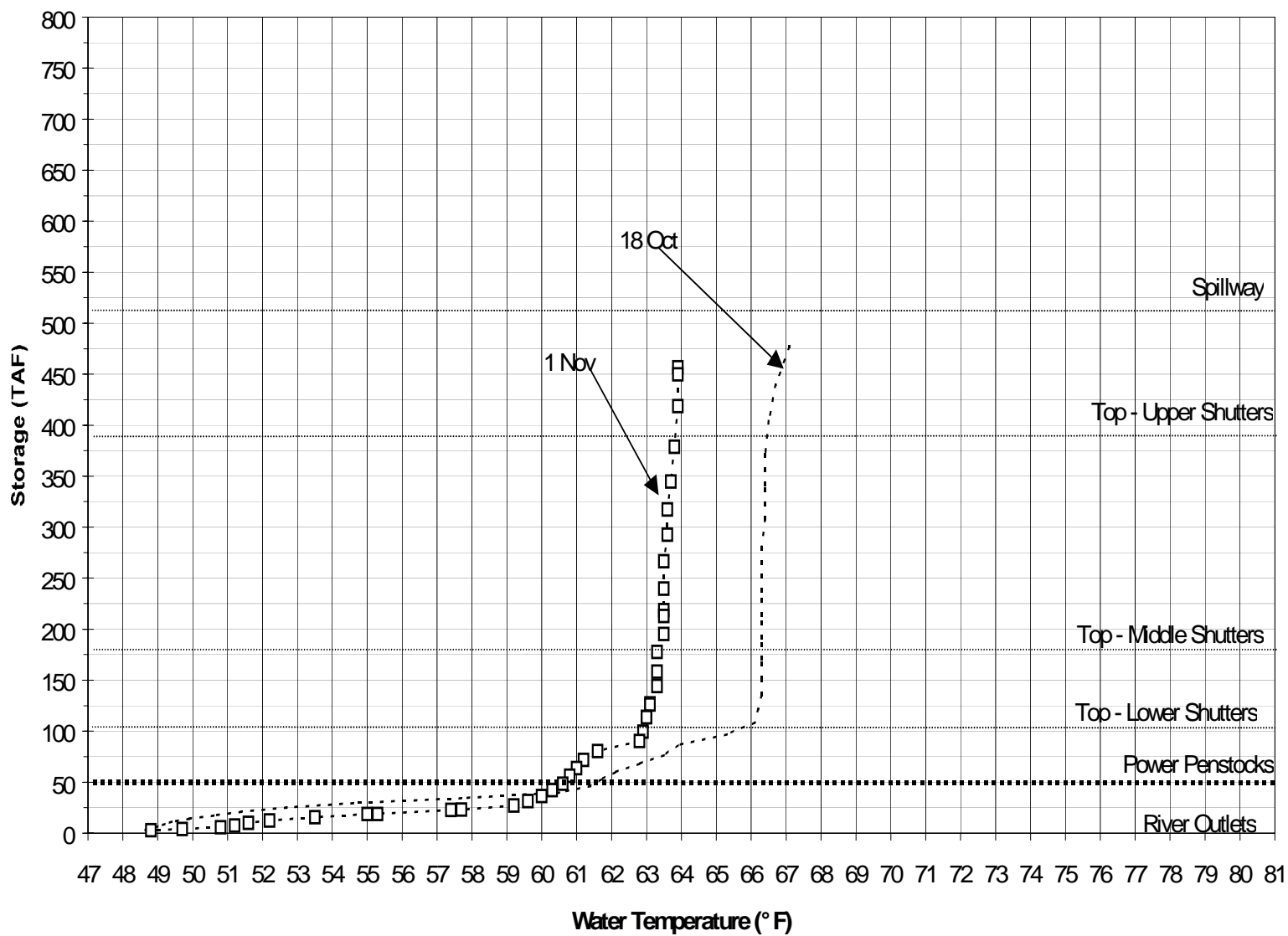


FIGURE 5.

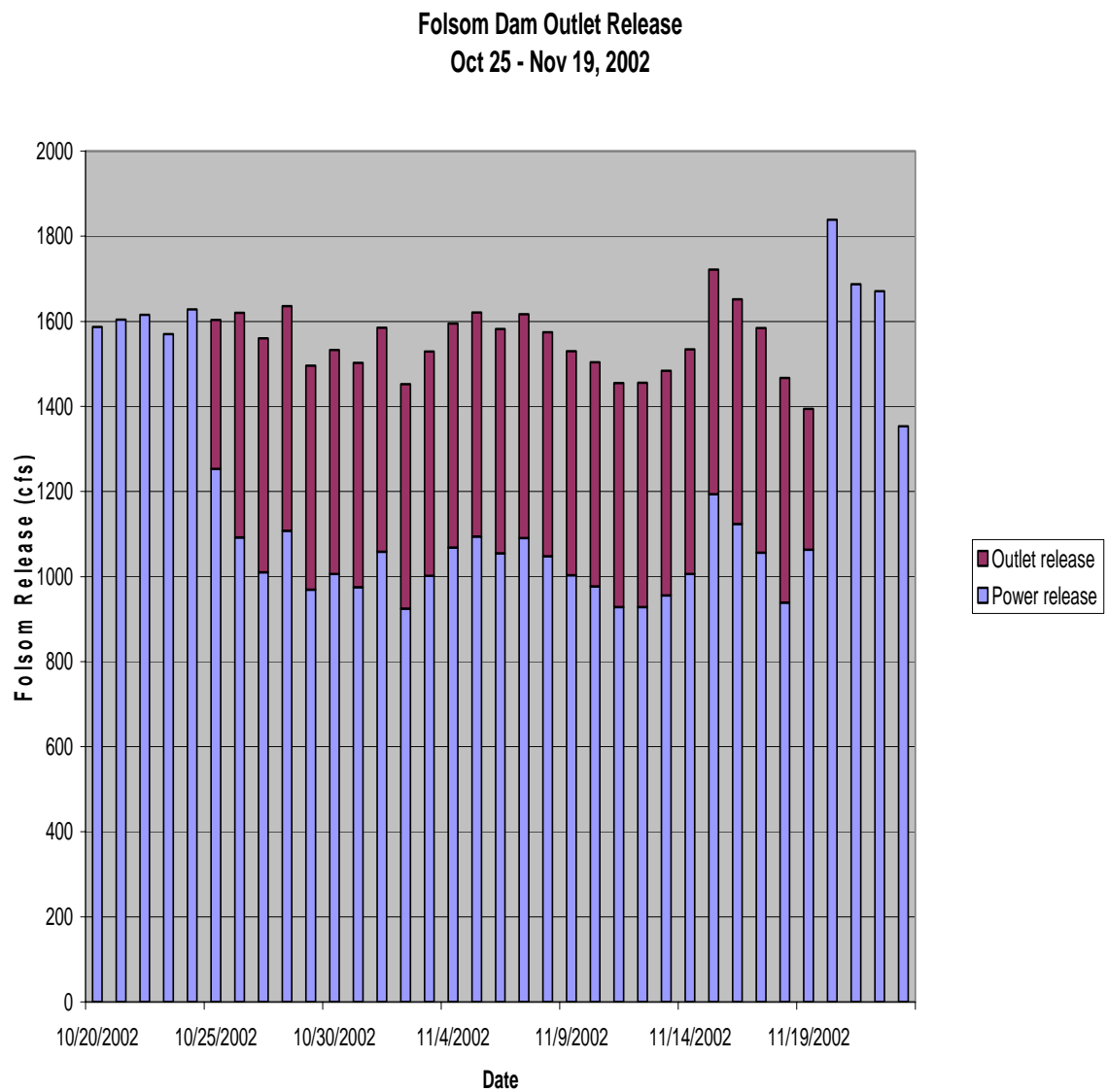


FIGURE 6.

Summary for Folsom Lake and Lower American River - October 2002

Day	Mean Daily Water Temperature (° F)							EOP Stor (TAF)	Release (cfs)	Sacramento Mean Daily Air Temperature (° F)
	NFA	ARP	AFD	Penstock Units 1-3	AHZ	AWP	AWB	Folsom	Nimbus	
1	64.3	#	64.6	O M(65) L(35)	63.8	64.2	64.8	507.3	1,508	66
2	62.4	#	64.4	O M(65) L(35)	63.0	63.4	63.4	505.0	1,506	68
3	61.6	#	63.1	O M(65) L(35)	62.2	63.3	63.7	502.6	1,507	69
4	62.6	#	62.5	O M(65) L(35)	63.2	64.2	64.9	500.6	1,505	73
5	63.7	#	64.7	O M(65) L(35)	63.8	65.0	65.8	498.6	1,505	75
6	64.5	#	63.0	O M(65) L(35)	63.8	65.4	66.5	496.9	1,508	76
7	64.9	#	61.7	O M(65) L(35)	64.5	65.6	66.7	494.9	1,512	79
8	65.2	#	64.3	O M(65) L(35)	64.5	66.0	67.1	494.0	1,508	79
9	65.1	#	64.2	O M(65) L(35)	64.1	65.6	66.7	493.5	1,506	77
10	64.5	#	64.1	O M(65) L(35)	64.0	64.5	65.2	492.3	1,504	65
11	63.4	#	62.7	O M(65) L(35)	63.9	64.3	64.3	490.5	1,506	66
12	62.4	#	62.8	O M(65) L(35)	63.8	64.5	64.9	488.4	1,507	69
13	62.2	#	63.7	O M(65) L(35)	63.6	64.6	65.1	486.0	1,504	72
14	62.1	#	63.8	O M(65) L(35)	63.7	64.6	65.2	483.5	1,508	75
15	61.6	#	62.8	O M(65) L(35)	63.7	64.3	64.8	482.4	1,511	65
16	61.4	#	63.4	O M(65) L(35)	63.5	64.0	64.3	480.6	1,507	64
17	60.8	#	62.6	O M(65) L(35)	63.2	63.8	63.9	479.0	1,504	63
18	60.4	#	62.9	O M(65) L(35)	62.8	63.5	63.7	477.1	1,511	62
19	60.4	#	63.1	O M(65) L(35)	62.9	63.6	63.8	474.3	1,507	67
20	60.3	#	63.2	O M(65) L(35)	63.0	63.7	64.1	471.1	1,503	67
21	60.2	#	62.8	O M(65) L(35)	63.0	63.7	64.2	468.7	1,507	69
22	59.8	#	62.6	O M(65) L(35)	63.2	63.6	63.9	467.1	1,501	61
23	59.5	#	62.6	O M(65) L(35)	63.0	63.3	63.3	464.8	1,505	57
24	57.1	#	62.9	O M(65) L(35)	62.5	62.5	62.3	463.7	1,502	56
25	54.2	#	* 59.9	O M(0) L(100)	62.0	62.6	62.7	463.6	1,503	63
26	53.8	#	* 57.9	O M(0) L(100)	61.9	62.3	62.4	462.4	1,507	62
27	54.1	#	* 57.7	O M(0) L(100)	60.2	61.7	62.2	460.5	1,564	63
28	53.3	#	* 57.6	O M(0) L(100)	59.1	60.4	61.1	459.4	1,503	65
29	52.6	#	* 57.5	O L(0) L(100)	58.4	59.5	60.0	458.4	1,503	63
30	51.9	#	* 57.4	O L(0) L(100)	58.2	58.9	59.0	457.4	1,502	60
31	51.2	#	* 57.3	O L(0) L(100)	57.7	58.3	58.2	456.8	1,511	55
Average	60.0		62.1		62.6	63.4	63.8		1,508	67
Total af									92,717	

! Includes incomplete or estimated data

Station out of service

* See notes on next page

N Data not recorded or collected

Shutter Position (U-Upper raised; M-Middle raised; L-Lower raised; A-All lowered; O-Unit Offline)

Penstock Unit Blending (a value in parentheses represents approximate % total daily load)

FIGURE 7.

Summary for Folsom Lake and Lower American River - November 2002

Day	Mean Daily Water Temperature (° F)							EOP Stor (TAF)	Release (cfs)	Sacramento Mean Daily Air Temperature (° F)	
	NFA	ARP	AFD	Penstock Units 1-3	AHZ	AWP	AWB	Folsom	Nimbus		
1	50.5	50.5	* 57.2	O L(50) L(50)	57.7	57.7	57.5	456.6	1,502	55	
2	49.9	49.6	* 57.0	O L(50) L(50)	57.2	57.4	57.2	455.7	1,502	54	
3	49.7	50.0	* 57.2	O L(50) L(50)	57.0	57.4	57.2	454.1	1,509	59	
4	49.6	49.9	* 57.1	O L(50) L(50)	56.8	57.2	57.1	453.7	1,500	58	
5	49.7	49.4	* 56.8	O L(0) L(100)	56.8	57.2	57.1	452.5	1,504	59	
6	50.0	49.6	* 57.1	O L(50) L(50)	56.8	57.1	57.0	451.0	1,504	57	
7	51.2	51.2	* 57.6	O L(50) L(50)	56.7	57.3	57.4	450.8	1,506	60	
8	53.9	53.0	* 57.9	O L(50) L(50)	56.5	57.9	58.3	451.3	1,509	63	
9	55.1	52.1	* 58.3	O L(50) L(50)	56.9	57.5	57.6	455.4	1,511	59	
10	54.2	51.7	* 58.4	O L(50) L(50)	57.4	57.6	57.4	456.0	1,504	57	
11	53.1	51.8	* 58.0	O L(50) L(50)	57.3	58.0	58.0	458.4	1,504	58	
12	52.6	51.2	* 57.6	O L(50) L(50)	57.6	58.3	58.2	460.2	1,503	61	
13	53.4	51.7	* 57.4	O L(50) L(50)	57.6	58.4	58.7	460.8	1,504	60	
14	52.7	50.7	* 57.6	O L(50) L(50)	57.7	58.2	58.1	461.4	1,506	60	
15	51.8	49.7	* 57.8	O L(50) L(50)	57.5	58.0	57.9	461.8	1,505	57	
16	51.8	49.6	* 57.8	O L(50) L(50)	57.4	58.0	58.0	461.8	1,504	56	
17	51.4	49.9	* 57.4	O L(50) L(50)	57.4	57.7	57.6	460.5	1,507	55	
18	50.6	49.3	* 57.4	O L(50) L(50)	57.3	57.6	57.2	459.8	1,502	56	
19	50.4	48.8	* 57.5	O L(50) L(50)	57.0	57.4	57.0	459.8	1,510	53	
20	50.9	49.3	57.9	O L(50) L(50)	57.0	57.5	57.4	458.2	1,509	58	
21	51.4	49.3	57.8	O L(50) L(50)	57.2	57.6	57.4	457.4	1,504	!	59
22	52.1	49.8	57.5	O L(50) L(50)	57.4	57.8	57.6	456.3	1,508	!	56
23	52.5	50.8	57.7	O L(0) L(100)	57.5	57.6	57.5	455.9	1,738		52
24	52.2	50.9	57.5	O L(0) L(100)	57.3	57.5	57.3	453.4	1,758		55
25	51.6	50.9	57.5	O L(50) L(50)	56.9	57.4	57.2	452.2	1,756		59
26	49.7	48.6	57.3	O L(50) L(50)	56.7	56.8	56.3	452.0	1,755		55
27	49.2	48.0	57.2	O L(50) L(50)	56.5	56.6	56.2	451.1	1,753		52
28	49.1	47.8	57.0	O L(50) L(50)	56.6	56.6	56.2	449.7	1,752		53
29	48.1	46.7	56.8	O L(50) L(50)	56.5	56.5	56.0	447.8	1,759		53
30	47.5	46.5	56.6	O L(50) L(50)	56.3	56.1	55.5	446.5	1,753		49
Average	51.2	49.9	57.5		57.1	57.5	57.3		1,571		57
Total af									93,502		

! Includes incomplete or estimated data

Station out of service

* See notes on next page

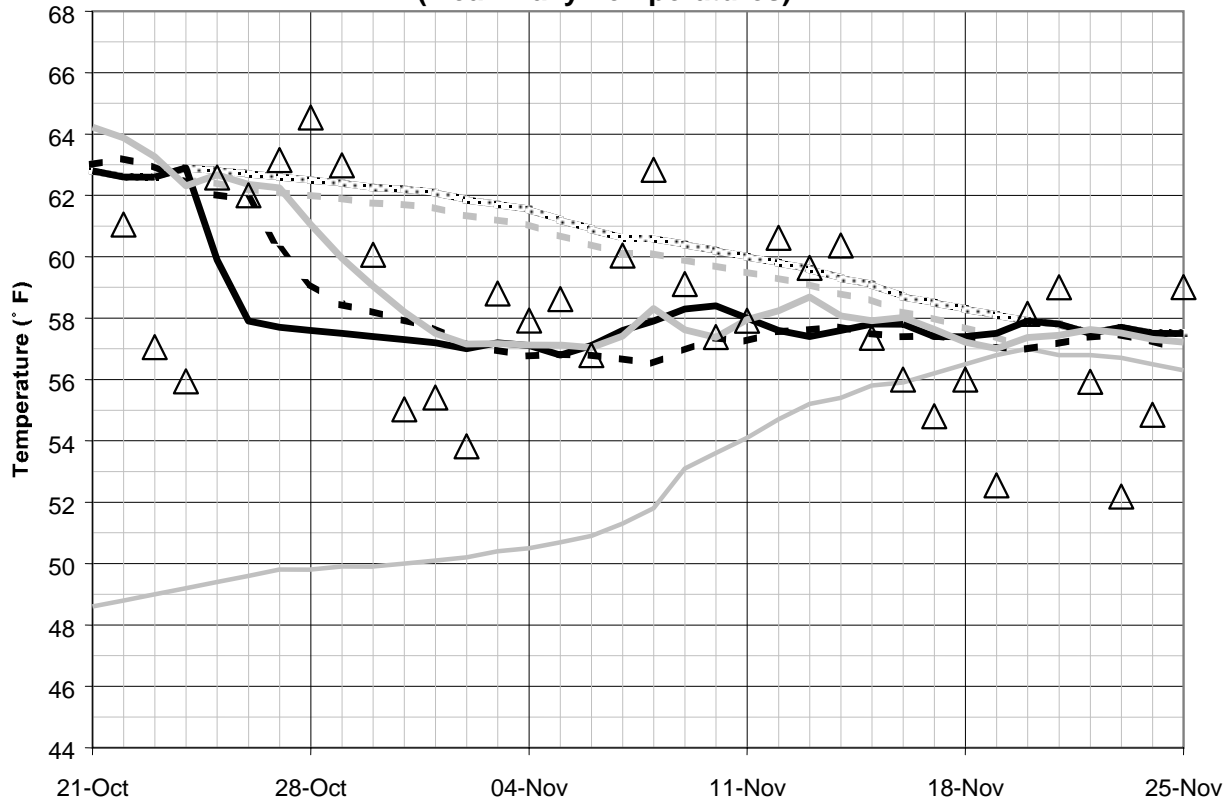
N Data not recorded or collected

Shutter Position (U-Upper raised; M-Middle raised; L-Lower raised; A-All lowered; O-Unit Offline)

Penstock Unit Blending (a value in parentheses represents approximate % total daily load)

FIGURE 8.

**American River below Folsom Dam
Estimated Effect of Penstock and River Outlet Blending
October 25 - November 19, 2002
(Mean Daily Temperatures)**



△ Air Temperature (SPO) Folsom Penstock	— River Outlets	— Nimbus w/o river outlets
— Folsom Release (AFD)	- - - Nimbus Release (AHZ)	— Watt Avenue Bridge (AWB)	

FIGURE 9.

**American River below Folsom Dam
Estimated Effect of Penstock and River Outlet Blending
10 - 26 November 2001
(Mean Daily Temperatures)**

